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Modern Concepts of Cardiovascular Disease

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TRAUMATIC RUPTURE OF THE PERICARDIUM

Traumatic rupture of the pericardium is practically always the result of thoracic compression, with or without fracture of ribs, sternum or vertebrae and, keeping pace with the modern machine age, is most frequently found in persons who have been struck or run over by automobiles. A small number are caused by falling from a height, crushing by machinery or by burying the body with earth or other solid material. The heart is likely to be penetrated only when bones of the thoracic cage are broken. On the other hand contusion and even strangulation of the heart may accompany or complicate pericardial tears produced by compression alone. The present summarization is concerned only with pericardial rupture occasioned by the application of blunt external force to the body.

Incidence: Although first described in 1706, the number of reported cases is still small, 80 instances, including 22 from the writers' own material. The literature has been infrequently summarized: Fischer, 1868, Schuster, 1880, Crynes and Hunter, 1939. Very probably autopsy statistics other than ours, with the same percentage of accidental and violent deaths, would yield similar figures. The paucity of published information is perhaps due to the fact that pericardial rupture is so often merely one of multiple traumatic injuries and in itself seldom figures significantly as a cause of death.

Location of Rupture: Many of the older descriptions are silent or inadequate on this point. However, a considerable number of these, and 13 of our 22 examples, had tears on the left side and mostly along the margo obtusus of the heart as compared with 4 right-sided ruptures. Multiple lacerations are distinctly uncommon. We found the heart protruding through the opening 7 times but only twice was this sufficient to leave constricting marks. As a rule the side on which the pericardium was torn corresponded to the direction of the applied force. However, in the presence of multiple points of injury it was not always possible to ascertain the direction of the lines of force.

Mechanism of Rupture: In the main two means of tearing appear to exist: (1) compression, and (2) laceration or puncture by the ends of fractured bones. A combination of the two is likewise possible, the pericardium bursting under the effects of pressure alone and before the bony cage gives way. In such instances, particularly when the pleura was torn by ribs, where it was at all possible for spicules of bone to have penetrated the pericardium, we have felt it safest to regard the lesions as penetrating wounds. On the other hand, when the broken ribs were so located that penetration of the pericardium was impossible it has seemed logical to classify the condition as a pure compression rupture of the pericardium. Lavalleé believed that when the heart and lungs were crushed against the vertebral column during an impact the pericardium might be torn by a shearing or rubbing motion of the membrane against bone. Much later Spitzmüller postulated that force even though not directly applied to the chest might be transmitted and initiate a pendulum-like swing of the heart of sufficient magnitude so that the impact against the pericardium might cause it to rupture. It would appear that an essential feature of such an explanation is the questionable assumption that the left border of the pericardium is weaker than any other since most ruptures occur here. Certain facts demonstrated in our material and by many previously recorded cases make it difficult to conceive of the possibility of any long sweeping motion of a structure so well stabilized against appreciable lateral motion by the short caval and pulmonary veins, as is the heart, without laceration or actual division of these vessels. In our series laceration of the inferior vena cava was invariably accom-

ANNOUNCEMENT

Papers for 1940 Scientific Sessions

Doctors wishing to participate in the 1940 Scientific Program of this Association to be held in New York City, on June 7, 1940, at the Hotel Roosevelt, must submit their abstracts before February 15 to Dr. Roy W. Scott, City Hospital, Cleveland, Ohio, who is Chairman of the Program Committee.

Those wishing to present papers at the Scientific Program of the Section for the Study of the Peripheral Circulation, to be held the following day, June 8, should also send their material before February 15 to Dr. William Goldring, 1088 Park Avenue, New York, N. Y., the Chairman of the Program Committee of this Section.

panied by fractured ribs so situated as to make it likely that they caused the damage. Also it is hard to imagine that the heart, moving for the short distance possible in a normal pericardial sac, could attain enough momentum to rupture such a strong sheath. Furthermore, Spitzmüller's theory fails to explain the relatively frequent rupture of the right aspect of the pericardium. Finally, he failed to take into account the almost constantly present evidences of injury to the soft parts of the chest or ribs in situations indicating that the impact was in an anteroposterior direction (as in the subject studied by him) wherein a pendulum motion of the heart can scarcely be imagined. With only slight modification the original explanation of Lavalleé recently convincingly shown by Beck to operate in traumatic rupture of the heart itself, will likewise apply to the pericardium even in the absence of fractured bones, namely: (1) forcible compression of the thorax with at least momentary springing of the ribs and resultant deformity of the bony cage; (2) impingement of the heart between the anterior and posterior thoracic walls at the moment of maximum intensity of the externally applied force and (3) in the event that the point of greatest intensity is broad the pericardial space may be completely closed at this level. If this chances to be over the heart itself the organ within the closed-off part of the sac may act as a fluid mass under tension. Then with the rapidly encroaching pressure they may be produced a relatively high internal expanding force within a membrane generally conceded to be incapable of stretching quickly. These are essentially the factors operating in a bag of fluid when squeezed at the top until the fabric breaks at some point. The site of pericardial rupture depends upon several factors, viz., the greatest free area or surface on which the expanding pressure is exerted, the direction of the applied force, the point at which the sac is closed off and finally, the side of the spine to which the compressed heart is displaced. The greater frequency of left-sided tears may be due to the fact that this is the largest free area of pericardium and for this reason possibly more vulnerable than the remainder. One authentic exception to the rule that direct trauma is required for pericardial rupture has been described (Kellert). In this instance the lower half of the body was buried by soft earth. Rupture was ascribed to greatly increased hydraulic pressure, driving the blood from the lower part of the body into the heart, causing both it and the pericardium to burst. The compression hypothesis should be applied only to pericardial ruptures without concomitant fractures unless these be so located that the possibility of penetration by bone ends can be excluded.

Diagnosis: For obvious reasons already given an ante-morten diagnosis will rarely be possible. Recognition at necropsy is entirely a matter of how carefully the examination is done. Only Lavalleé has described the clinical signs of pericardial rupture. A loud, double systolic "water-wheel" murmur with alternating loud and soft sounds that were sharply interrupted like the impact of water on the blades of an overshot wheel was audible in one subject. Lavalleé concluded that such tones could be made only by fluids, air, or both, being drawn in and out of the pericardial sac and that a pleuropericardial communication must exist. In a second man he heard at each seventh, fifteenth and twentieth pulsation and repeating itself four or five times, a murmur like that produced by blowing into an empty bottle. The sound vanished with the patient in the upright position and reappeared when he lay down. Later a precordial rub developed. In both instances the diagnosis of pleuropericardial communication on a traumatic basis was confirmed by necropsy. Intense precordial pain has been noted (Allen, Spitzmüller, Crynes and Hunter) but in our case at least fractured ribs best explained this symptom. An isolated wound of the pericardium not involving the blood vessels may be practically asymtomatic because the injured pericardium alone does not give rise to pain (Kosmin).

Complications: In persons surviving the immediate injury complications referable to pericardial rupture may be: (1) pneumo-pleuro-pericardium (Lavalleé); (2) pericarditis, either directly associated with trauma to the membrane or the heart, or secondary to pleuritis accompanying pneumonia. This is the greatest single hazard faced by those with congenitally deficient pericardium (Southworth and Stevenson), but is unlikely to be a factor in traumatic defects since so few cases of long survival occur; (3) an avenue of escape for blood into the pleural cavities or mediastinum is provided in the event of concomitant heart rupture, allowing death from exsanguination rather than by tamponade as occurs in rupture of the heart in the presence of an intact pericardium; (4) retraction of the torn margins with herniation, complete extrusion of the constantly moving heart, or a combination of the two may set the stage for strangulation of the heart and sudden death. This is best illustrated by a remarkable case in our group. A seven-year-old boy was run over by an auto trailer, sustaining fractures of the 3rd, 4th, and 5th left ribs at the costochondral junctions. For two and a half years thereafter mild attacks of pain which might have been due to temporary and intermittent escapes of the heart through the defective pericardium was the sole complaint. Finally, in apparent good health on retiring the child was found in a dying condition during the night. At autopsy the pericardium with smooth, white and pleated margins was found to have retracted until it formed a tight purse-string over the pulmonary artery and left atrium, the appendage of which it had inverted. The right heart and pulmonary conus were greatly dilated due to the marked compressing action of the pericardium over the pulmonary artery. Death was ascribed to acute pulmonary stenosis with right heart failure. The pericardium could be reapproximated along the long rent in its left border. Congenital malformation was excluded on this basis and the further fact that the phrenic nerves were normally situated. It seems impossible that the pericardium could have occupied the position in which it was found for longer than a few minutes. No similar cases were found in the literature.

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